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SCIENTIFIC-TECHNICAL ACHIEVEMENTS OF
THE CHINESE CHEMICAL INDUSTRY

By Hou Te-pang
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- COMMUNIST CHINA -

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FOREWORD

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SCIENTIFIC-TECHNICAL ACHIEVEMENTS OF THE CHINESE CHEMICAL INDUSTRY

- Communist China -

[Following is a translation of an article by Hou Te-pang, Vice-Minister of Chemical Industry, in K'o-hsueh Hsin-wen (Scientific News), No. 30, 28 September 1959, Peiping, pages 22-25 and 8.]

In the ten years since liberation, the development of the Chinese chemical industry has been rapid. Generally speaking, the degree of industrialization of a nation can be judged by the production of sulfuric acid and caustic soda. Metallurgy, petroleum, machine-building, fertilizer, organic chemicals, building material, textile and the paper-making industries are all directly or indirectly related to the sulfuric acid and caustic soda industry. Therefore, the production expansion of these two chemicals gives an indication of the development of the chemical industry as a whole.

<u>Production</u>	<u>Sulfuric Acid</u>	<u>Caustic Soda</u>
1949 Output	100%	100%
1957 Completion of 1st 5-Year Plan	1580%	575%
1958 Great Leap Forward	1860%	738%
1959 Estimated Fulfillment	2500%	910%

The development of agricultural chemicals and fertilizers, closely related to agriculture, has been rapid--the increase has been more than 40-fold. In the past, we produced only ammonium sulfate. No phosphorous or potassium fertilizers were produced. Now we are producing nitrogen fertilizers: ammonium nitrate, ammonium chloride, nitrate of lime, urea, ammonium bicarbonate, etc.; phosphorous fertilizers include superphosphates, calcium magnesium phosphate, calcium triple phosphates, nitrogen phosphate mix, etc.; potassium fertilizers: potassium sulfate, potassium chloride, nitrogen-potassium mix, etc. Other varieties, including magnesium fertilizer,

silicone fertilizer and trace fertilizers--such as molybdenum, boron, tungsten, zinc--have been gradually emphasized.

The immense development of the chemical industry has been the result of the leadership of the Party, the unselfish assistance of fraternal nations and the hard work of the labor force. Using imagination and tireless effort, which are characteristic of communism, the fighters on the chemical front have achieved the greatest victory. Looking into the future, today's technical achievement is only the beginning. Yet it has been a glorious beginning, the result of Party leadership, the combination of theory and practice. Industrial research is to meet the challenge of production; it serves production. Therefore, the immense development during the past ten years invariably leads to a great harvest of technical improvements. Let us examine the specifics.

Sulfuric Acid Industry

The successful production of vanadium catalyst has been a great contribution to this industry. One of the big acid plants, the Yung-li-ning, used to depend on Chemico and Monsanto of U.S.A. for vanadium catalyst. Practically all plants depended on import catalyst. If cut off from foreign catalyst supply, the industry would not have been able to produce, let alone expand. The manufacture of catalyst is a trade secret in capitalist nations. There is hardly any literature or detailed description on its manufacture. Because of intense research since liberation, we finally succeeded in its manufacture. The use of it in production has proved it to be equal to the best in the world, in its conversion efficiency, temperature resistance, corrosion resistance, and mechanical strength. So now all our acid plants, large and small, including the 400-ton compact plants, are able to manufacture vanadium catalyst. Recently we succeeded in the manufacture of a right type, low pressure drop, high surface area catalyst which will greatly improve conversion efficiency.

The utilization of the boiling roaster is another achievement in the industry. The Gay-Lussac system previously used excluded the use of low-grade iron pyrite, production was low and it needed high-temperature alloy and large equipment and construction investment. Our own designed roaster can take pyrite with as low as 18% sulfur. The production of each 3 m. dia. x 6 m. tower is 500 tons per day of 100% acid, nearly 10 times the production of the Gay-Lussac tower. Furthermore we are experimenting on a rotary burner that burns the ore more thoroughly, producing more concentrated sulfur dioxide and cinders with low sulfur content and making

it better for steel-making and extraction of precious metals.

The use of the Venturi gas scrubber in sulfuric acid production has been achieved in this country although there is hardly sufficient reports on its usage in foreign literature. After evolved from the rotary burner, the sulfur dioxide is cooled, and dust and droplets are removed. Dust content of 0.015 g/m^3 and acid entrainment of 0.024 g/m^3 can be achieved by the Venturi scrubber. This eliminates the need for dust and entrainment removers and large scrubbing towers and thus saves on materials and investment and simplifies the flow sheet. The limitations of the Venturi scrubber are (1) it must be installed beside a constantly flowing river so that the acid-containing water can be disposed of and (2) a slightly higher acid loss.

Facilities for a tower-type sulfuric acid plant need a large amount of lead and lead alloys. Learning from the advanced experiences of the Soviet Union, our new installations have substituted those metals with carbon steel and cast iron, thus effecting a great saving of precious non-ferrous metals and yet have produced acid of international standard.

Soda Industry

Both the efficiencies of carbonating towers and calciners exceed that of capitalist nations. In the past, six towers were operated in series--five for production and one for cleaning. We are now operating 12 towers in series, thus reducing down time, increasing operating cycle and at the same time increasing production per tower. In a 2 m dia. x 22 m carbonating tower, which in capitalistic nations produces 60 tons of pure soda ash in 24 hours, our tower produces 84 tons with 75% conversion. The same is true in the calciner. In a 2 m dia. x 18.3 m calciner, which in capitalist nations the production is 50 tons, we can produce 85 tons. This fact emphasizes the superiority of the socialist system; the working class is master of production. Therefore it is possible to improve with the spirit of cooperation and to make magnificent achievements not possible under the capitalist system.

Another improvement of the industry is the steam heat calciner. It has 3 to 4 times the capacity of the external-fired calciner of same size. The utilization of heat is 75% or better, with longer life for the equipment and better working conditions. High temperature in the surrounding area is eliminated and the presence of soda particles are absent from the steam calciner. The production is 275 tons of pure soda per calciner per day. The results of our design has been excellent and the performance data have been exchanged with fraternal nations.

The successful use of the wet cyclone centrifuge in the soda industry is another meaningful technical revolution. Cleaning milk of lime with the wet cyclone has resulted in reducing sand content from 23 kg/m³ to 0.23 kg/m³, an efficiency of better than 99%, thus increasing the purity of soda ash and sodium bicarbonate and reducing the complexity of purification. Furthermore, with the use of the wet cyclone we are experimenting with the recovery of calcium and magnesium in the brine purification stage. There are possibilities that the wet cyclone can be utilized on causticizing of lime and the separation of recycle brine. If this is successful there will be immense saving in the purification operations.

Continuous process of soda manufacture was discovered by us in 1941, yet it was not till after liberation that we started to build such facilities, enabling this important process to be realized economically. The Solvay process has a low utilization efficiency of salt and a large amount of waste which creates handling problems. Now we have put together the soda and ammonia industries to produce soda and ammonium chloride, thus increasing the utilization efficiency of salt to 95%. This makes use of chlorine, reducing the consumption of lime and the amount of waste produced. Ammonium chloride is a fertilizer equivalent to ammonium sulfate. This means huge saving of sulfuric acid for other uses, lessening the ever-increasing demand for acid. This improvement has made news internationally. Under the leadership of the Party, we have built a 3,000 ton/year soda and ammonium chloride pilot plant and are about to build a 300,000 ton/year plant. Actual practice has proved the superiority of this combination. It has also improved some of the traditional equipment. This combination has realized the simplification of facilities, reduction of investment, and reduced production costs.

In the soda ash industry we are now able to manufacture large current rectifiers, chlorine compressors, automatic controllers of hydrogens, etc. Improvement is especially great in electrolytic cells. The rectangular diaphragm cell (T'ien-Yuan No. 16), one of the best, is widely used in China. Its advantages are compactness and high current. The cathode height is 740 mm (experimenting on increase to 900 mm) and a current of 15,000 to 20,000 ampere is passed. This means a 100% increase in output. Moreover, small current density and low potential make possible a 20% saving in electricity over the horizontal electrolytic trough, and with an electrical efficiency of 95% to 96%, there is concentrated solution, low electrode consumption and purer chlorine. In the horizontal electrolytic trough the flat cathode is replaced by the "wave" configuration and the graphite anode changed to triangular

configuration, thus greatly increasing the effective surface of both electrodes, increasing production and decreasing voltage.

Learning from the advanced technology of the Soviet Union, we have manufactured the Le Blanc evaporator. This is better than the rotary evaporator in that it saves structural material, has higher efficiency, has better than 2.5 m/sec liquid velocity to avoid scaling, and consumes less electricity. In solid soda ash, after using the continuous process, we have achieved 99.5% of the export standard.

The soda industry has also achieved huge success during the great leap forward in utilizing waste products. In the Solvay process the most appalling problem is the waste product of ammonia stills. Waste piled up near plants and the calcium chloride waste liquid destroys plant life, contaminates water sources and makes the ground "muddy". Now this waste product is being utilized in cement manufacturing with a resultant product of No. 400 standard. Utilizing by-products is one of the important technological improvements. Furthermore, extracting magnesium carbonate and calcium carbonate from the waste in brine operation has also been successful. These are used as rubber filler and heat insulation materials.

Fertilizer Industry

We have succeeded in manufacturing 2,400 H.P. and 5,000 H.P. 6-stage high pressure compressors, high pressure reaction chambers, small and large high pressure seamless tubes and high pressure vessels. Thus we are able to manufacture and maintain the complete assembly of ammonia plants. This has not only laid the foundation of the ammonia industry but has also provide the foundation of high pressure organic synthesis and synthetic gasoline industries. The manufacturing of high pressure vessels has never been done before. In capitalist nations iron vessels are not permitted to be used in pressure applications over 100 psi. But with skill in steel making, welding, heat treatment and inspection, we have overcome the difficulties. Discarding superstition, utilizing bold action and creativity, we have made good quality high pressure vessels, proven in the ammonia industry. For instance, the 800 mm dia. vessel designed for 200°C and 320 atmospheres has a bursting limit of 1,500 to 1,800 kg/cm². This is a safety factor of five. The manufacture of a 300 mm 1,500 atm. polypropylene reactor is also under study. The forged steel high pressure reactor is more economical in construction than either the jacket type or clad vessels. Our skill has

proved to be the equal or better than international standards, and we have invented methods that never existed before. We have also perfected, after study, the heavy wall welding technique, resulting in welds stronger than that in the parent metal.

The manufacture of iron catalyst for ammonia synthesis by melting has a long history in China. The product has proved to be the equal in activity, mechanical strength and poison resistance of the best from abroad. Using electrolytic hydrogen, efficiency has equaled 70 tons of ammonia per cubic meter catalyst per 24 hours and 53 tons of ammonia per cubic meter catalyst per 24 hours in large installations, compared to the 30-35 tons in capitalist nations. This proves the superiority of our catalyst. Our progress is also superior in conversion (iron-magnesium) catalyst and other catalysts used in the petroleum industry and organic synthetic industry.

In exploring new sources of raw material, we have substituted anthracite for coke in large scale operations and have achieved a consumption of 1.3 to 1.4 tons of anthracite per ton of ammonia. Gasification of bituminous and partial oxidation of natural gas or coke oven gas as source of hydrogen have also been explored.

A new approach, the use of ammonium bicarbonate as fertilizer has been undertaken; this has not even been tried in the world. The manufacture of ammonium bicarbonate requires simpler facility than ammonium sulfate and needs less stainless steel. Ammonium bicarbonate has no bad effects on soil and the carbon dioxide can also be absorbed by plants in synthesis of chlorophyll. Therefore it has a higher utilization than ammonium sulfate and ammonium nitrate. It requires only coal or charcoal as raw material, and does not consume nitric acid or sulfuric acid. Yet it must be protected against heat and moisture because it decomposes above 35°C, particularly in humid climate. Because of the demand for fertilizers created by agricultural advances, this problem of storage is not serious. It is suitable for production by small plants for local consumption.

The use of the semi-counter-current method has been perfected in direct extraction of 45% phosphorous pentoxide phosphoric acid. This eliminates recycle and at the same time produces concentrate phosphoric acid without concentration operation. The consumption of sulfuric acid is 89-100% of theoretical and the efficiency of extraction is 98.88% or better. As soon as we solve the problem of corrosion material, full scale production will follow.

The production of calcium and magnesium fertilizers by

high furnace has already succeeded. The raw materials are widely found throughout the country. These fertilizers can be used in either acidic or alkali soils. This method is simpler and easy to utilize. Now we are able to recover about 4-6% nickel.

Agricultural Chemical Industry

In the field of agricultural chemicals we have established production techniques for more than 100 chemicals. The consumption of benzene in "666" is more than 300 kg with 13% stabilized isomer content in foreign product as standard; we consume 278-280 kg/ton and have achieved 14% isomer content. Non-toxic isomers and substitutes of copper-containing and mercury-containing agricultural chemical have been studied and have been produce in small quantity. Research on chloride production of cyclopentanes, high potent organic phosphorous insecticides, insecticide "SR-400", plant growth accelerators, etc., have been successful.

In particular we should mention that during the great leap forward, we discovered countless agricultural insecticides, including the "broken bowl flower", which was commended by Chairman Mao. In a short time, the Encyclopedia of Chinese Native Agricultural Medicine was compiled, which has immense economic as well as scientific implications. This publication is a join effort of botanists, chemists, entomologists, agricultural experts, etc., and is further evidence of successful "grass root" investigation. In studying the effect of insecticides, three factors should be considered: 1. The characteristics of the insecticide--chemical and physical properties, diffusion characteristics, dosage. 2. The characteristics of the pest--physiology, life cycles, feeding habits, etc. 3. Enviromental characteristics--climate, soil characteristics and characteristics of the plants it is applied to, etc. In application, the considerations are: formulation and compounding with powder or solvent; methods of application--spraying or smoking, etc. In describing the advances in this field, we must mention the joint efforts of all the hard working personnel who made these things possible.

Inorganic Salt Industry

Inorganic salts are important raw materials of the chemical industry. Materials that we depended on formerly from foreign supply, including sodium perchromate the source of other chromic compounds; sodium perborate, excellent bleach,

ammonium persulfate--a good oxidizer, have been successfully manufactured.

The manufacturing of metallic sodium, potassium, calcium and semi-conductor grade silicone and germanium by electrolytic methods and reduction method have achieved a purity of seven 9's. Fifteen rare-earth elements have been refined to spectrographic grade, after only a short period of research, and have earned praise abroad. We have also produced 99.88% pure platinum, 99.848% pure beryllium and extracted selenium from sulfuric acid waste. In barium chloride we have achieved a calcium content of less than 2/10,000 while the British first grade is 3.5/10,000. Stannic oxide manufactured in Shanghai, rejected by the British in 1952 as "inferior quality," has been improved, substituting electric arc sublimation with acidic roasting. Now the purity has been advanced to 99.5% and the product is exported to Czechoslovakia, Egypt, Western Germany and sought by the British.

Using sea brine as raw material we have produced gypsum, magnesium sulfate, magnesium chloride, potassium chloride, halogens, etc., all derived from brine. Our edible salt production has reached 13,000,000 tons in 1959. Brine is becoming an important chemical raw material. The Ministries of Light Industry and Chemical Industry have launched a large-scale research effort to establish production.

Organic Chemical Industry

In the rural areas, because of good harvests, the development of waste utilization has been rapid. From distillation of rice husks we have obtained methol, acetone, glacial acetic acid, phenol, etc. Then by hydrolysis aldehyde is obtained. The rate is about one kg sulfuric acid per one kg of aldehyde. The gas evolved from distillation serves as fuel for power. In a survey in Kwangtung, 1/6 of the gas is consumed in grain processing and the other 5/6 is supplied for industrial use, contributing greatly to the industrialization of people's commune.

After distillation the residue can also be used as activated carbon and in the manufacturing of water glass, etc. The yield of rice husks is extremely great in China and about 6 million chin of this can be used to produce raw material for the chemical industry. From the inner shells of rice, oil and vitamin B can be extracted.

Following the development of distillation of coal, study has been underway on the utilization of high phenols in low boiling tar. By catalyst cracking or by hydrogenation

some of them are transformed to low phenols. They are used as adhesive, antiseptics and selective agent of mineral ore. Using low boiling tar and formaldehyde as raw materials, acid or soda as catalyst and by direct polymerization we produce phenol-formaldehyde copolymer. It withstands 900 kg/cm² pressure, withstands 150°C for 30 minutes with no deformation and has wide use in molding products, thus saving benzene and phenol for other uses. This is another example of the comprehensive utilization of raw materials.

In polymer research we have scored several breakthroughs and have produced high quality products. Silicone resin has been used in 2,500 kw turbine generators manufactured by us. Organic titanium resin withstands 500-550°C, and sudden chilling does not chip or discolor. High strength varnishes and wire varnishes withstand 120-130°C, abrasion by knife, high voltage, twisting, etc. Varnish used by our "Flying Dove" bicycle has color, brightness, impact strength and hardness comparable to the best in British bicycles. Ship paints, under actual test have surpassed the "Red Hand" brand of the British.

In the field of low molecular weight resins, polytetrafluoroethylene, polyformaldehyde and other ion exchange resins have also been successfully studied.

In the field of dyestuffs, the great achievement is the perfection of activated dye. It was invented by the British in 1956 and its structure contains activated sites and reacts with fabric, thus is resistant to repeated wear. Under the brilliant leadership of the Party we have created great varieties of them and after evaluation, 18 have been found to be the best on a comparative basis. The Red variety even surpasses the British made. Another variety is a cool dye, which eliminates the effect of infrared light, making it ideal for military uniforms.

In the field of synthetic rubber, we have manufactured high temperature silicone rubber and oil and cold resistant butyl rubber. Besides we have created an "alloy" of rubber and plastic which retains the characteristics of both and has new, useful properties. They all have important meaning in national defence and to the economy.

Rubber Industry

Tires with steel cord, produced only in France, have been successfully manufactured. Steel wire is used in place of fabric cord. The advantages are: 1. Steel wire has 4-5 times the strength of fabric cords. Usually 2 to 3 layers of steel cord is equivalent to 8-14 layers of fabric. This

enables a thinner tire body, thus saving rubber. 2. Better heat transfer characteristics enable the tires to have longer life. 3. Can withstand heavier load, be recapped many more times. The record abroad has been 600,000 km. 5. Better resistance to blowout, safer.

Development work is also going on in cordless tires made only in France, and tires made directly from latex, which is under study in England, but not yet in production.

Air suspension in automobiles and trains is under development. Air suspension has been under test in automobiles for 30,000 km without breakdown. It has also been tested on trains on the Peiping-Tientsin Railway with excellent result. In the future it can replace many steel springs in machines. This would save the use of metal and prolong service life, with lower cost and better "ride." Using latex and bristle, we have succeeded in making foam rubber for use in aircraft, automobiles, and beds to replace steel spring.

In the transportation of chemicals and petroleum, we have developed collapsible rubber drums. These drums replace metal ones and reduce freight cost on empty, return trips. Quartz axial, used in paper making, was entirely imported before; now we can manufacture it. Rubber bearings and gears used in ships are also now made by us.

The ascending height of 2,000 g. meteorological balloons has reached international standards. The quality of our seamless ball bulbs is comparable to that of West Germany, the sole manufacturer of such. Surgical gloves and other related products have increased in variety and the experiences gained have been exchanged with fraternal nations.

Pharmaceutical Industry

In antibiotics, in addition to penicillin, streptomycin, broad-spectrums [combination types], aureomycin, tetracyclin, etc., there has been the recent addition of multigranular bactericin--best for treatment of bacillus chlorinus in burns, and antimycin--best against bacteremia due to burns. All these have been proved by clinical tests. We have also produced actinomycin K, a good drug for lymphadenoma, with good clinical results.

Animal organs are a good source of biochemicals, for which reliance was on imports in the past. We have now successfully extracted about 60 compounds and are self-sufficient. The adrenal gland extract ACTH comes from the pituitary of the pig, is in wide clinical use and is a cure for arthritis. Success in the extraction of heparin and

insulin has resulted in the saving of much foreign exchange and these drugs are cheaper than imports.

Pituitary extracts were exclusively imported in the past. Now, because of intensive research efforts, several varieties have been produced. These can cure chronic miscarriages, impotence and arthritis. Now on markets abroad are progesterone, gonadotropic hormones [testiculin], testosterone propionate, cortisone, dehydrocortisone, methyltestosterone, etc., -- all in all some 20 varieties.

Under the leadership of the Party, we have developed, using steroids from yams and sweet potatoes as starting materials, the synthesis of progesterone, gonadotropic hormones and testosterone propionate and have begun production. Cortisone and corticoids (考的甾) from the steroid of yam have also been made in small quantities. Steroids are extracted from the yellow yam by petroleum ether followed by hydrolysis with sulfuric acid.

The yellow yam is a plant containing mainly carbohydrates. The plant grows wild and in abundance in Yunnan, Kweichow, Kiangsi, Kwangsi, Chekiang, and in the Northeast. However, this plant should be used judiciously, systematically harvested and planted, so this valuable resource is preserved.

The great Tenth Anniversary is approaching. With such glowing achievements behind us, we should firmly resolve, under the leadership of the Party and Chairman Mao, and under the brilliance of the general line, to forge ahead with combination of striving vigor and scientific analysis.

Let us all raise our voices: Long live the general line! Long live the people's communes! Long live the great leap forward!